Vol. V No. 1
1977

STUDIES ON SOIL TRANSMITTED HELMINTHIC INFECTION AMONG COAL MINERS IN SAWAH LUNTO, WEST SUMATRA*

Runizar Roesin[1], B.C. Dazo[2], Liliana Hardjawidjaja[3], Muslim[4], Amiruddin Nagga5 and P. Hedrick[6].

Prevalensi cacing perut diantara karyawan tambang batu bara Ombilin Sawah Lunto adalah 91,2 persen, 39,8 persen dan 13,persen masing-masing untuk cacing tambang, Ascaris lumbricoides dan Trichuris trichiura.

Sebagian besar karyawan tambang bati bara ini menderita anemia (hanya 13,3 persen diantara mereka yang mempunyai kadar haemoglobin dalam batas-batas normal). Ukuran persen diantara mereka yang mempunyai kadar haemoglobin dalam batas-batas normal). Ukuran anthropometrik menunjukkan bahwa hanya 62,5 persen berat badan untuk tinggi badan karyawan tambang ini termasuk kategori 90 persen atau lebih standard nasional yang diusulkan.

Percobaan pengobatan dengan menggunakan tetramisole (ascaridil) menunjukkan bahwa obat ini memberikan hasil yang memuaskan hanya untuk infestasi A. lumbricoides.

It was observed that the majority of workers of the Ombilin coal mining company in Sawah Lunto were suffering from anemia and upon stool examination, they were found positive for hookworm infection. Since, the company did not have the necessary facilities and staff to assess the problem, the medical officer sent an urgent request to the Directorate general of the Communicable Disease Control (CDC) Ministry of Health, Jakarta for assistence.

A team of workers from the CDC and National Institute of Health Research & Development, Ministry of Health, Jakarta and a W.H.O. Consultant visited Sawah Lunto in February 1975 and conducted this investigation whose aims were as follows: 1) to assess the problem of soil transmitted helminthic infection among coal miners. 2) to carry out a limited drug trial to find out the efficacy of tetramisole (ascaridil); and 3) on the basis of the results of this study, to design and implement an effective and economical program for the control of soil transmitted helminthic infection.

These objectives were in line with the recommendations of Kosin (1973) and Karjadi (1974) who advocated immediate control measures against hookworm infestation.

Description of the study area.

Sawah Lunto is a small town located Northeast about 90 kilometers from Padang, the capital of West Sumatra. It is surrounded by hills and mountains on all sides, so that the term "Kota Kuali" applies to the town. During the 1920's Sawah Lunto developed after coal was discovered in the area.

All miners originally came from Java and during the peak coal productivity, the town had a population of about 40.000. This was

---

* This paper was presented in the Third National Seminar on Occupational Health and Safety, 20 – 25 October, 1975, in Surabaya.

1 C.D.C.; Ministry of Health, Jakarta
2 W.H.O. Consultant Project Indonesia ESD 002 SEARO
3 National Institute of Health Research and Development, Jakarta
4 Department of Parasitology, University of Andalas, Padang.
5 Coal Mining Company Production Unit Ombilin, Sawah Lunto
6 WHO Statistician, Project Indonesia ESD 002 SEARO.

Received 10 Januari 1977.

at a time when coal was an important source of energy. During the ensuing years when oil was discovered and utilized as a primary source of energy, coal decreased in importance. As a result the town of Sawah Lunto also declined in economic importance and consequently in population. The first generation of miners were from Java and it could be said that the profession was passed on from generation to generation.

Only a minority of the local population worked as miners in this coal company. The miners lived in dormitory-type residences sharing the same housing facilities, water supplies, toilets, kitchens etc. Foot-wear was seldomly used among the miners and the majority of them had large families.

The town was almost at a stand still during the attempted closing of the mining company in 1973 and 1974, but at present there is a likelihood it will grow again because of the blessing in disguise of the so called energy crisis by which, coal is again considered to be an important source of energy.

Sawah Lunto is divided into two parts by a stream that flows through the middle of it. At present it is a multipurpose stream beacuse it is used as the source of drinking water, throwing garbage, waste disposal, washing coal, etc.

It has one big hospital with 210 beds and one new Health Centre. During the previous golden times of coal, the basic hygiene and sanitation was appropriately good and the hospital which was owned and managed by the coal company could be regarded as a good hospital and one of the best in the whole province. At present the hospital is under-utilized, lacking supplies, equipment and personnel. It is no longer under the management of the coal mining company.

MATERIALS AND METHODS.

At present there are 1,619 miners at Ombilin coal mining company of whom, only 377 individuals were taken as a random sample. These miners were divided into 5 groups according to their places of residence, namely. Group 1 (Tangsi Baru), Group 2 (Karang Anyar), Group 3 (Durian I), Group 4 (Durian II) and Group 5 (Sikalang).

Individual heights and weights were taken and hemoglobin level was determined colorimetrically (Klett Summerson). A blood film slide was also prepared for malarial parasite detection. Stool samples were microscopically examined using Kato's modified technique as described by Kato et al (1973) and modified Harada Mori's method (Kosin and Sulianti Saroso 1973). Two thick slide preparations and one sample for Harada Mori were made from each stool specimen. The measurement of height and weight and blood sample was taken at night between 07:30 p.m.–09:30 p.m. in the meeting hall of the above residence areas.
Before going home each worker was given a plastic stool container to be filled with faeces which was collected the following morning. Ascaridil tablets were given to each individual and taken with water in the presence of a member of the team. Dosage followed were: Group 1 was given 150 mg tetramisole, group 2, 150 mg in two successive days, group 3, 150 mg in three successive days and group 4 was given only a tablet of vitamin B6 and could be regarded as a control group and group 5 was also given 150 mg tetramisole. Members of their families were not included in this drug treatment trial. The result of the limited drug trial was evaluated 10 days after treatment in order to evaluate the direct effect of ascaridil.

RESULTS

Characteristics of survey population: Initially 386 miners were selected for the study, but nine of these were not available for follow-up with the result that the main study was restricted to 377 miners. These miners were all adults, mainly between 30 to 49years of age; some 82 percent being within these age groupings, the majority of the remainder being 20 to 29 year of age.

The initial examination revealed an exceptionally high prevalence of soil transmitted helminthic infection among the miners.

Table 1 Prevalence of soil transmitted helminthic infections among the coal miners of Ombilin on initial stool examination

Treatment group. Village	Number followed-up	Percentage prevalence of soil transmitted helmithic infections		
		A. lumbricoides	*T. trichiura*	Hookworm*
1. Tangsi Baru	76	32.9	9.2	75.0 **
2. Karang Anyar	78	46.2	25.6 **	100.0 **
3. Durian I	74	51.4 **	51.4 **	95.9
4. Durian II	79	40.5	8.9	93.7
5. Sikalang	70	27.1 **	17.1	91.4
TOTAL	377	39.8	13.0	91.2

* The dominant species of hookworm in the Sawah Lunto area is N. americanus (the ratio between N. americanus and A. duodenale is 259 : 3.)
** Denotes a significantly different prevalence percentage from that for all other groups combined

These figures indicated that soil transmitted helminthic infection was a serious health problem in the community, the rates for hookworm and *Ascaris lumbricoides* being particularly high. The rates in fact, could have even been higher as the results were based on paired slides preparation from a single stool specimen. The figures also showed that differences existed in the prevalence rates of diseases between the five villages. Thus the results of any treatment trial would have to take account of these differences, especially if the results are not clear-cut.

In order to obtain a comparative basis for assessing the prevalence rates of soil transmitted helminthic infection among the miners, stool examinations were undertaken for a sample of the families of the miners (230 out of 2,058). The results are summarised in table 2.

There were only small differences in the rates between sexes while by ages the only significant difference relates to the hookworm rate

Table 2 Prevalence of soil transmitted helminthic infection among families of the coal miners of Ombilin

(a) By Sex.

Parasite	No. of stool examined		No. of positive stools		Prevalence rate per 100.	
	male	female	male	female	male	female
A.lumbricoides	89	141	45	71	50.6	50.4
T.trichiura	89	141	8	17	9.0	12.1
Hookworm	89	141	29	48	32.6	34.0

(b) By Age.

Parasite	Age in years				
	0 – 4	5 – 10	11 – 20	21 + ...	All ages
Number Examined	48	80	49	53	230
A.lumbricoides	%	%	%	%	%
A.lumbricoides	41.7	60.0	46.9	47.2	50.4
T.trichiura	8.3	7.5	14.3	15.1	10.9
Hookworm	12.5	36.3	40.8	41.8	33.5

for children aged 0 to 4 years which, as one would expect, was significantly lower than for all other age groups. However the most important finding relates to a comparison of the prevalence rates for adult (21 + years) family members when compared with those for the miners.

Table 3 Comparison of prevalence rates of oil transmitted helminthic infection between miners of Ombilin and adult family members.

	Miners Percent	Adult family members Percent
A. lumbricoides	39.8	47.2
T. trichiura	13.0	15.1
Hookworm	91.2	41.5

These figures clearly confirmed the original fear that the miners, because of their working environment were subject to exceptionally high risks of hookworm infections.

The differences in rates between the miners and their families are not significant for *A lumbricoides* and *Trichuris trichiura* but for hookworm the differences are clearly established.

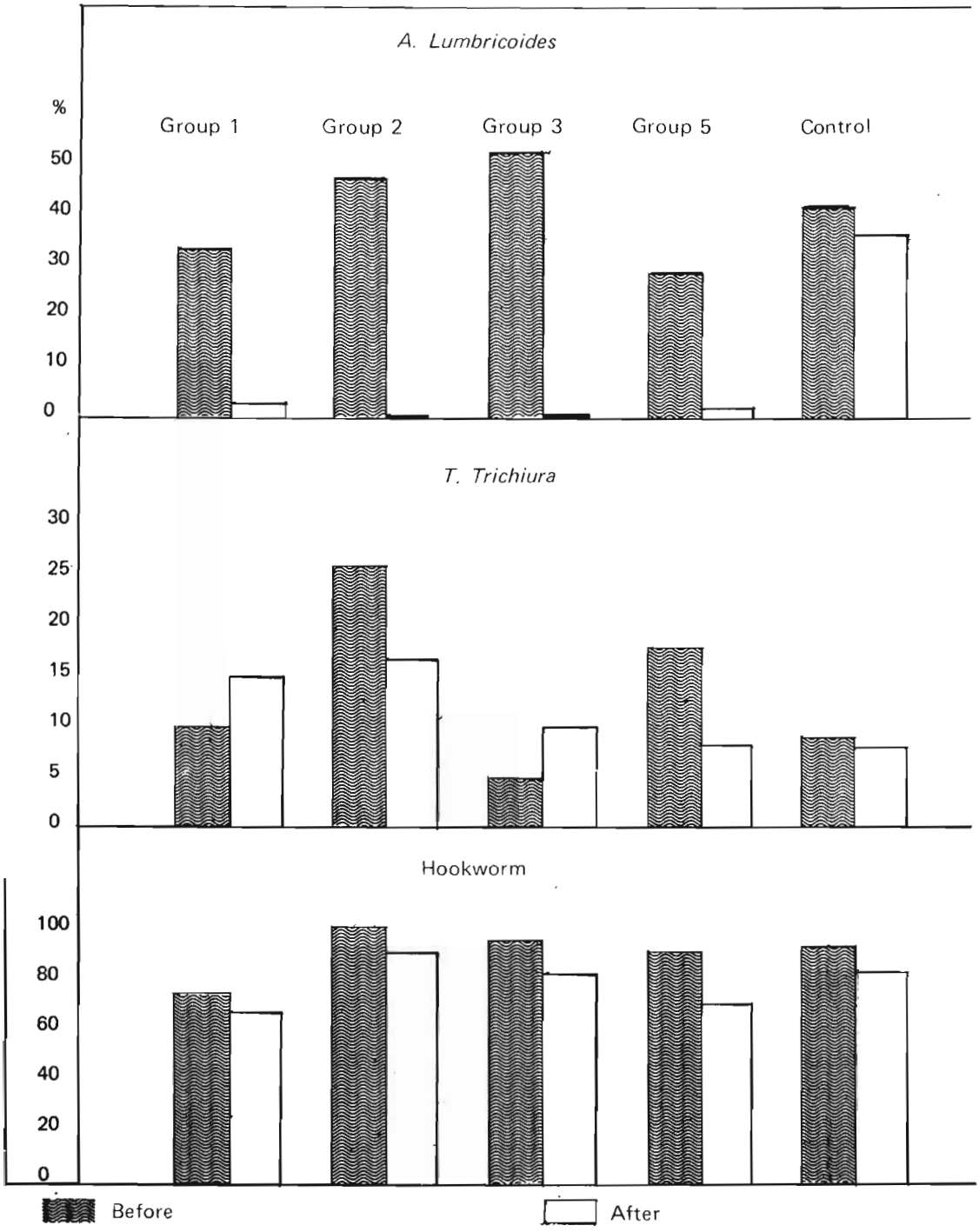

Fig. Effect of tetramisole on percentage prevalence rote for *A. Lumbricoides, T. Trichiura* and Hookworm. Group 1 = 1 day treatment, Group 3 = 3 days treatment, Group 4 = control, Group 2 = 2 days treatment, Grup 5 = 1 day treatment

An important consideration in assessing the results of the treatment trial was the physical condition of the miners. The physical condition could not be expected to be good as over 90 percent were suffering from soil transmitted helminthic infection and over half had more than one form of the infection.

Table 4 Types of soil transmitted helminthic infection found on initial examination of coal miners of Ombilin.

Parasite	Number	Percentage.
No. parasite found	32	8.5
Hookworm only	173	45.9
Hookworm and *A. lumbricoides*	122	32.3
Hookworm and *T. trichiura*	22	3.8
Hookworm, *A. lumbricoides* and *T. trichiura*	27	7.2
A. lumbricoides Only	1	3
Total	377	100.0

The combined effect on the miners of a life of hard work, the impact of debilitating diseases and other factors such as poor nutrition was reflected in their anthropometric measures and their haemoglobin readings. The anthropometric measurements, i.e. body weight for height showed that in relation to the proposed Indonesian National Standard only 62.5 percent were within 10 percent of the proposed national norm. Likewise the miners had below-average haemoglobin readings.

Table 5 Haemoglobin readings before treatment of coal miners of Ombilin

Hemoglobin ia grams %	Number	Percentage
Under 8	32	8.5
8 to less than 9	22	5.7
9 to less than 10	58	15.4
10 to less than 11	56	14.9
11 to less than 12	46	12.2
12 to less than 13	55	14.6
13 to less than 14	58	15.4
14 and above	50	13.3
Total	377	100.0

The Arithmetic mean haemoglobin reading was 10.9 gms percent with a standard deviation of 2.56 gms percent and a standard error of the mean of - 90. The seriousness of the above figures can perhaps be realised that King has found that the normal readings for males in developing countries is in the range 14 to 18 gms percent. According to this criteria only 13.3 percent of the miners had normal readings. Equally important was the fact that some 30 percent of the miners had haemoglobin readings of less than 10 gms percent, which suggests that there was an extremely high rate of anaemia among the miners.

Treatment Results : The results of the tetramisole treatment trial showed that the drug was effective against the infection of *A. lumbricoides*

The drug had a dramatic effect on the infection. Only three cases were positive on the examination after 10 days and these were all patients who had received only one day treatment. On the other hand 116 cases were found to be negative on re-examination after treatment. The number of cases not responding to treatment was too small to enable a conclusion to be reached on whether one day treatment was insufficient.

For *T. trichiura* the treatment had little or no effect in reducingt the case load as is seen in Table 7 and Figure summarising the results of treatment.

There had been a slight reduction in the number of positive cases among those who received treatment, but there was also a reduction in the control group. The reduction among the positives is not significant. The difficulty of obtaining an accurate prevalence rate for T. *trichiura* from the examination of only one stool specimen is reflected in this table. There were 24 cases which were negative on first examination but positive on re-examination 10 days later. The egg counts for the *T. trichiura* patients were relatively low, averaging only 87 per gram of faeces with a considerable proportion having counts under 50 per gram.

If the 24 cases who were only positive on

Table 6 Result of stool examination for A. *lumbricoides* before treatment and 10 days after treatment with tetramisole.

Group	Treatment	Stool examination result				Positive on first exam			Positive on second exam	
		Before	+	+	–	–	Total	No.	Percent	No.	Percent
		After	+	–	–	+					
1.	*1 day*		*1*	*24*	*50*	1	76	25	32.9	2	2.6
2.	2 days		–	36	42	–	78	36	46.2	–	–
3.	3 days		–	38	36	–	74	38	51.4	–	–
5.	1 day		1	18	51	–	70	19	27.1	1	1.4
	Sub - total		2	116	179	1	298	118	39.6	3	1.0
4.	Control		24	8	43	4	79	32	40.5	28	35.4

Table 7 Result of stool examination for *T. trichiura* before treatment and 10 days after treatment with tetramisole.

Group	Treatment	Stool examination result				*Positive* on first exam			Positive on second exam	
		Before	+	+	–	–	Total	No.	%	No.	%
		After	+	–	–	+					
1.	1 Day		5	2	63	6	76	7	9.2	11	14.5
2.	2 Days		7	13	51	7	78	20	25.6	14	17.9
3.	3 Days		–	3	67	4	74	3	4.1	7	9.5
4.	1 Day		3	9	55	3	70	12	17.1	6	8.5
	Sub total		15	27	236	20	298	42	14.1	38	12.8
4.	Control		5	2	68	4	79	7	8.9	6	7.6

re-examination were included with the first group of positives, then a prevalence rate of 19,4 percent is obtained against the overall rate of 13.0 percent cited in table 1.

Table 8 Arithmetic mean egg count per gram of faeces for T. *trichiura* cases before and after treatment with tetramisole.

Group	All positive cases		Cases positive in both test	
	Before	After	Before	After
1.	66.9	55.6	83.2	88.4
2.	94.3	38.9	92.9	48.3
3.	17.3	13.0	–	–
4.	49.8	17.3	34.7	17.3
Sub total	72.6	38.2	78.0	55.5
4.	182.0	111.2	96.2	184.6

The possibility was also considered that the dosage of the drug may not have been sufficient to effect a complete cure. In such circumstances, it could have been expected that the egg count for the positive cases would be reduced.

The numbers from which the means for the individual groups were calculated were exceedingly small, the majority being under 10 and this prevented any wide-ranging conclusions for being drawn. There was a reduction in mean egg counts for those receiving treatment, but a paired t-test applied to the egg counts of those who were positive in both tests showed

Table 9 Result of stool examination for hookworm before treatment and 10 days after treatment with tetramisole.

Group treatment	Stool examination result					Positive on first exam		Positive on second exam	
	Before after	+ +	+ −	− −	− +	To - tal	No.	percent	No.	percent
1. 1 days		44	13	12	7	76	57	75.0	51	67.1
2. 2 days		71	7	−	−	78	78	100,00	71	91.0
3. 3 days		59	12	1	2	74	71	95.9	61	82.4
4. 1 day		50	14	2	4	1 70	64	91.4	54	77.1
Sub total		224	46	15	13	298	270	90.6	237	79.5
4. Control		63	11	2	3	79	74	93.7	66	83.5

that the reduction was not significant.

Tetramisole was also found to be ineffective in the treatment of hookworm infections. Taken overall there is a reduction of 11.1 percent in the number of hookworm cases among those who received treatment with tetramisole. By itself, this would be a significant reduction, but the control group who only received a tablet of vitamin B6, experienced a reduction of 10.2 percent in the number of cases. The net difference of 9 percent is in no way significant. Expressed another way, of 270 found positive with hookworm on the initial examination and treated with tetramisole, only 46 converted to negative after ten days and many of these conversions may be the result of the other factors. The drug cannot therefore be regarded as an effective means of curing hookworm infestation.

Much the same picture was revealed by examination of the mean egg counts before and after treatment. Because there was such a wide fluctuation in hookworm egg counts, in this study from 13 to over 19.000, the geometric mean rather than the more frequently used arithmetic mean has been taken as the measure of central value. The arithmetic mean is the sum of the values divided by the number of observations while the geometric mean is obtained by multiplying the values together and taking a root equivalent to the number of observations. The computation of the geometric mean is usually done by using logarithms. In the case of hookworm infestation, the arithmetic mean would be somewhere around 1000 eggs per gram of faeces while the geometric mean and the median would be around 300 eggs per gram of faeces. There were wide fluctuations in the mean egg count from one group to another, which made it difficult to interpret the data. Uemura has demonstrated a method of undertaking statistical analysis of hookworm egg count data, by first transforming the individual observations into units of geometrical progression. The normal statistical tests can then be applied using these working units.

Applying paired t-test and analysis of variance to those cases who were positive under both tests revealed that significant reductions have occurred in the egg counts of

Table 10 Geometric mean egg count per gram of faeces for hookworm cases before and after treatment with tetramisole.

Group	All positive cases		Cases positive in both test	
	Before	After	Before	After
1.	166.4	99.7	195.4	152.6
2.	355.7	287.0	388.8	188.8
3.	173.0	163.7	214.5	204.1
5.	467.2	127.7	298.3	169.7
Sub− total	250.2	145.6	280.0	181.6
Control	403.5	250.5	432.0	282.2

groups 2 and 5 of those who received tetramisole but not groups 1 and 3. The overall mean for all treatment groups (1,2,3 and 5) was also significantly lower. However the importance of this finding was diminished by the fact that the control group also had experienced a significant reduction in the mean egg count (one-tail test of significance only). The interpretation was further complicated by the fact that the pattern of reduction experienced by groups 1 and 3 differed markedly from that of the other three groups.

On the whole, it appeared that the drug, tetramisole had some slight effect both on the prevalence of cases and the density of infestations of hookworm, but the effect was not sufficient to consider tetramisole as an efficient means of treatment.

Correlation between haemoglobin and density of hookworm infestation: Besides the treatment trial of tetramisole, two subsidiary studies were also undertaken, one related to the possible correlation of haemoglobin and hookworm density and the other to the relative effectiveness of the Kato technique and the Harada Mori technique for confirming the presence of hookworm.

The hookworm egg count density and the haemoglobin readings of 295 miners who were initially found positive for hookworm under the Kato test are set out in table 11. The data for hookworm infestations were broken down in a geometric progression of the power base of $\sqrt{3}$ to enable the geometric mean to be calculated.

A faint pattern was discernible in that the means for those miners with haemoglobin readings of under 8 and 8 to less than 9 gms percent were higher than the means for other readings. To assess the significance of this possible correlation, 30 observations were selected at random from 295 positive cases and attempts made to fit these observations into the linear or a curvilinear pattern. The coefficient of determination (a general measure of the degree of correlationship between egg

Table 11 Haemoglobin readings and density of hookworm infestations among miners Umbilin.

Egg count per gram faeces	Haemoglobin eading (gms percent)								
	Under 8	8 < 9	9 <10	10 <11	11 <12	12 <13	13 <14	14 +	Total
1	–	–	–	–	–	–	–	–	–
2 – 3	–	–	–	–	–	–	–	–	–
4 – 5	–	–	–	–	–	–	–	–	–
6 – 9	–	–	–	–	–	–	–	–	–
10 – 17	1	1	3	2	3	–	4	1	14
18 – 29	3	1	1	5	3	4	2	2	21
30 – 51	1	–	–	3	–	2	3	1	10
52 – 89	–	3	9	4	4	5	6	4	35
90 – 155	–	1	6	6	4	7	9	4	37
156 – 269	2	1	5	5	1	6	3	4	27
270 – 467	3	–	5	10	4	5	4	4	35
468 – 809	6	3	6	3	4	6	2	5	35
810 – 1402	2	6	9	2	3	3	5	6	36
1403 – 2429	5	1	1	4	4	1	3	3	22
2430 – 4208	1	1	2	1	1	4	–	–	10
4209 – 7289	–	–	–	–	1	–	1	1	3
7290 – 12626	1	1	2	2	1	–	–	–	7
12627 – 21879	1	–	–	–	–	1	–	1	3
Total	26	18	49	47	33	44	42	36	295
Geometric mean	492.3	510.7	286.3	216,7	270.0	262,2	165.4	327.0	273.9

The scale for egg count is a geometric progression calculated from a base 3.

counts and haemoglobin readings were as follows):

Table 12 Coefficient of determination (r^2) between hookworm egg counts and haemoglobin readings among coal miners of Ombilin.

Type of fitting	Coefficient of determination
Linear Regression	.02
Exponential Curve Fit	.01
Power Curve Fit	.02
Logarithmic Curve Fit	.02

These readings show that only one to two per cent of the variation in haemoglobin readings can be explained by the density of hookworm egg count. Care must be exercised in interpreting this finding as both the haemoglobin reading and the egg count were a one-time reading. It is possible that in a more detailed study measuring haemoglobin and egg counts over a period of time and taking into account the duration of illness, the physical condition of the patient and his nutritional status that a more definite form of correlation might be established. Comparison of Kato technique and Harada Mori technique: In order to test for hookworm each stool sample was microscopically examined using Kato's modified technique and a modified Harada Mori method. It was found in the assessment of the actual results that a misleading conclusion could be obtained if the positives were based on the results form only one of the techniques.

Table 13 Comparison of results of initial hookworm examination of the stool samples from miners using Kato technique and Modified Harada Mori technique.

Type of technique	Number examined	Number positive	Percentage positive.
Kato test	377	295	78.2
Harada Mori test	377	329	87.3
Positive on either test	377	344	91.2

Even the combined results are slightly understated as there were 16 miners who were negative under both tests on the first examination of their stool but whose second sample 10 days later was found to be positive. Some of these 16 cases at least were probably already infected at the time of the first examination.

In this assessment of the effectiveness of tetramisole in treating hookworm, a case was regarded as positive if he was found positive under either of the two techniques.

DISCUSSION

From the results of this limited study it could be concluded that: hookworm infection seemed to be public health problems in this relatively closed community of miners because of the high prevalence rate (91.2 percent) and that the majority of miners were anemic (only 13.3 percent of the miners had normal haemoglobin readings). These cases of anemia should not be attributed to malaria because only two out of 176 blood samples were positive for malaria. The anthropometric measurement and their haemoglobin readings indicated that the miners' nutritional state was not good. In a place such as this community of miners where many people were under nourished, the clinical manifestation of hookworm infestation particularly anemia was obvious.

Hookworm disease is an occupational disease among the miners, because their environment in the coal mining area seems to be favourable for the transmission of hookworm Preventive measures were not taken as footwears were lacking and hygiene and sanitation was rather poor.

From the results of tetramisole treatment trial it could be seen that tetramisole was only effective for the treatment of ascariasis.

SUMMARY

A total of 377 adult male workers at Ombilin Coal Mining Company in Sawah Lunto, West Sumatra were the subjects of t

study. These miners were found to have an exceptionally high prevalence of soil transmitted helminthic infection presumably due to their working environment and lack of necessary footwear for preventive measures. The rates obtained were as follows : hookworm (both *Necator americanus* and *Ancylostoma duodenale)*, 91.2 percent, *A. lumbricoides*, 39.8 percent, and *T. trichiura* 13.0 percent only 8.5 percent of those examined were found free from any soil transmitted helminthic infection.

Based on Maurice Kings' standard haemoglobin level for males in developing countries, only 13.3 percent of the miners studied had normal readings, i,e. 14 – 18 grams percent.

A limited drug trial using tetramisole (ascaridil) revealed that the drug at the dosages of 150 mg per day for one, two and three consecutive days was effective against *A. lumbricoides* but practically ineffective against *hookworm and T trichiura* infections.

ACKNOWLEDGEMENTS.

The authors would like to express their gratitude fo Mr. Prasadja D. Sugoto, chief of Production Unit Ombilin, coal mining company, Sawah Lunto who provided some parts of the facilities in the field, Prof. J. Sulianti Saroso M.D., DR., PH., Chief of the National Institute of Health Research and Development for her support in conducting this study, L. Ratna Pundarika M.D., M.Sc., for her statistical advice, Mr. Fachroery Thojib B.Sc., for his assistance in processing the data.

REFERENCES

Bahrawi W., Parasite Control and Family Planning Programme in Indonesia (1975) Proceeding, the Second Conference of the Asian Parasite Control Organization, Tokyo, Japan.

Karyadi, (1974). Hubungan ketahanan pisik dengan keadaan gizi dan anemi gizi besi (Thesis untuk memperoleh gelar Doktor dalam Ilmu Kedokteran pada Universitas Indonesia di Jakarta) Bab VI : 103

Katz, N.; Chaves, A and Pellegrino, J.; (1973) A simple device for quantitative determination of *Schistosoma mansoni* eggs in faeces examined by the thick – smear techniques.
W.H.O. / Schisto/73.26, 1 – 6.

King, Maurice (1973). A Medical Laboratory for Developing Countries. Oxford University Paris, London, Delhi, Kuala Lumpur

Kosin, E., (1973). Some aspect on the treatment of ascariasis and hookworm infection in North Sumatra. Seminar on public health research, Jakarta, 30 July – 4 Agustus 1973.

Kosin, E., Timbul, L.T., and Saroso, J.S., (1973). Suatu cara yang sederhana untuk membiakkan tempayak nematoda (A simple method for culturing larvae stage nematodes). Maj. Kedokteran Indonesia (J. Indon. Med/Ass.), 23 : 7–10

Uemura, K. (1964) Statistical Analysis of Data in Bilharziasis Research. W.H.O. unpublished mimeographed Document BILH/Exp. Com 3/INF/8.64